

H₂O, H₂S and O₂ measurements for carbon capture, utilization, and storage (CCUS) applications

Benefits at a glance

- Reliable H₂O, H₂S, and O₂ analysis in CO₂ processes and pipelines
- High equipment availability due to durable design and proven reliability
- Improved safety, process control, and quality validation at key CCUS measurement points
- Accurate, real-time measurements without interferences
- No consumables and very low maintenance for low cost of ownership
- Easy to install and commission with remote monitoring for hands-off operation for years
- Simple in-field service for minimal downtime
- NIST-traceable calibration
- Compatible with ASTM test methods, and global hazardous area certifications

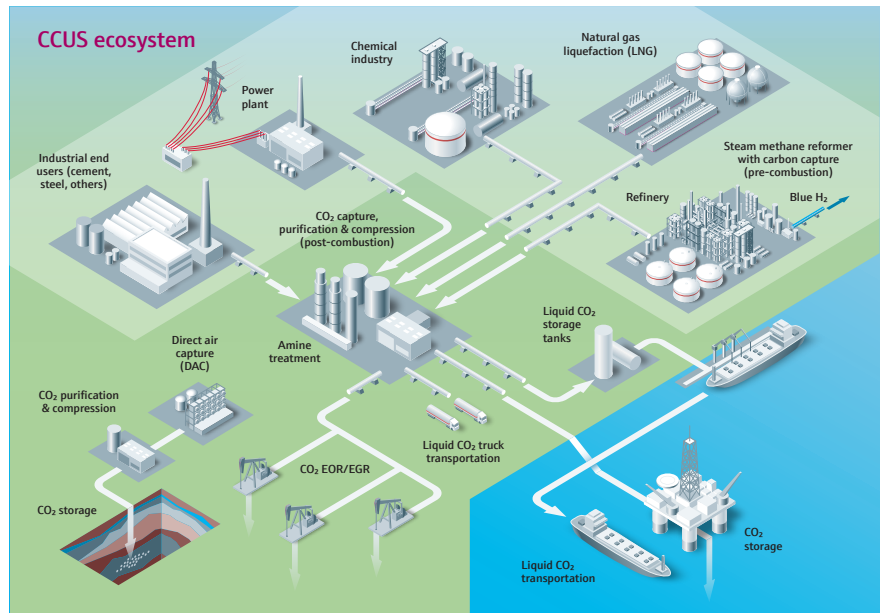


Figure 1: CCUS ecosystem

Rapid, reliable analysis of moisture (H₂O), hydrogen sulfide (H₂S), and oxygen (O₂) in carbon dioxide streams is vital to ensure safety, process control, and gas quality for carbon capture, utilization, and storage (CCUS) applications.

Energy transition and CCUS

Innovative measurement technologies are required to meet defined targets set by the United Nations Convention on Climate Change – to reduce global carbon dioxide emissions by 45% by 2030 (relative to 2010 levels) and to net zero by 2050. CCUS is an approach that can help to achieve these goals. CCUS involves separating CO₂ from fossil power generation or industrial sources (or the atmosphere) and transporting it for reuse or permanent deep geological storage.

CCUS measurement challenges

CO₂ pipelines can be susceptible to corrosion, and the presence of H₂O, H₂S, and O₂ can accelerate the corrosion rate. Measuring the concentration of these impurities helps pipeline operators control carbon removal processes and ensure that the CO₂ meets quality specifications.

Rapid, reliable readings of these compounds provide process validation, enable regulatory compliance, and ensure pipeline integrity.

Many traditional measurement technologies have sensors that come in direct contact with CO₂ streams and are adversely affected by other gas components, resulting in errors, interferences, and failures. Ultimately, these analyzers often deliver unreliable measurements. They also cause lengthy downtimes and are costly to operate.

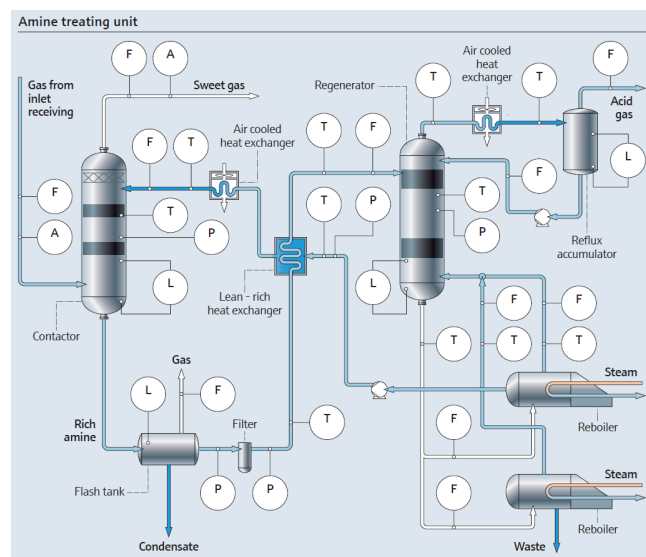


Figure 2: Amine treatment showing analysis (A) measurement points

Carbon capture and quality validation

One of the primary techniques for CO₂ capture is via chemical absorption using an amine treatment process. Amine gas scrubbing is highly effective for removing H₂S and separating CO₂. As shown in Figure 2, the exhaust gas is cooled and pumped into a chamber where chemical “scrubbers” bind to H₂S and CO₂ molecules. High-performance analyzers are then needed to perform a vital quality validation check of the CO₂ stream to ensure it meets specifications and regulatory standards.

Additionally, the presence of oxygen can affect the performance and efficiency of the amine plant. For example, it can react with the amine solvent and reduce its ability to absorb CO₂. Measuring the oxygen concentration allows operators to optimize the process to ensure maximum efficiency.

For information about the use of Raman spectroscopy to measure CO₂ in amine gas scrubbers, refer the application note, [“Quantitative in-line measurement of CO₂ loading in amine gas scrubbers.”](#)

For a case study on the use of Raman technology for CCUS processes, please see [“Optimizing carbon capture processes through Raman spectroscopy.”](#)

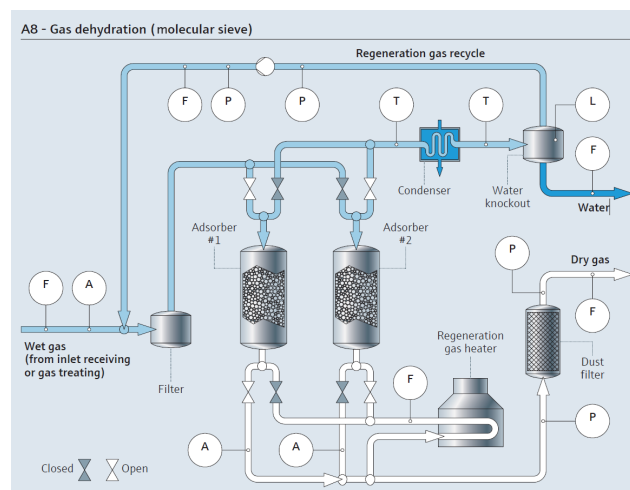


Figure 3: Molecular sieve dehydration process analysis (A) measurement points

CO₂ transportation

Before being compressed and transported via pipelines, the captured CO₂ must be dehydrated. Dehydration is necessary to avoid corrosion and ice/hydrate formation at high pressures. It is most commonly achieved using methods such as glycol or molecular sieve drying. A precise moisture measurement needs to be taken to maximize dehydration efficiency (Figure 3). After dehydration, the gaseous CO₂ is compressed and liquefied to make it ready for transportation. Here again, it is important to get a reliable moisture measurement to prevent condensation and subsequent corrosion from occurring at compressor stations.

During transport, CO₂ pipelines are at high risk of corrosion when subjected to H₂O, H₂S, and O₂. On-line, rapid and continuous analysis is required to detect these unwanted contaminants in the CO₂ stream to maintain ongoing pipeline and process integrity.

Recycled & stored CO₂

Compressed CO₂ can be recycled for use in products such as carbonated beverages or as feedstock for chemical reactions. Another traditional technique to reuse and store captured CO₂ is enhanced oil recovery (EOR). EOR is a win-win from both an economic and a climate change perspective. Injecting recycled CO₂ into mature oil fields can significantly boost oil production, yet the majority of CO₂ remains sequestered underground without being emitted into the atmosphere. To prevent corrosion and freezups, reliable measurement of H₂O and H₂S is crucial. Additionally, total CO₂ quantity can be measured to determine the level of impurities, such as nitrogen and hydrogen, which can affect phase characteristics in the pipe (Figure 4).

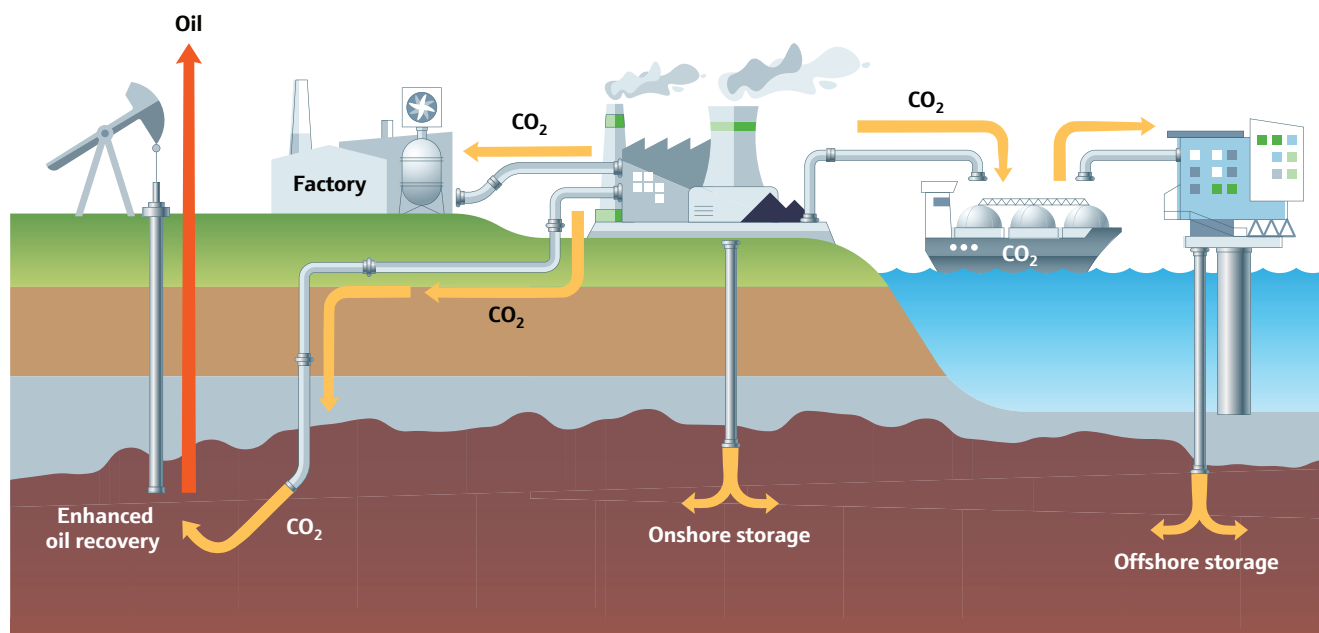


Figure 4: Applications of CO₂ storage and reuse

Endress+Hauser's solution

Endress+Hauser tunable diode laser absorption spectroscopy (TDLAS) and quenched fluorescence (QF) analyzers have proven reliability for numerous CCUS applications at installations worldwide. The laser-based technology provides real-time, non-contact measurements. Endress+Hauser TDLAS gas analyzers successfully monitor the amine sweetening process for carbon capture, accurately measuring H₂S in the CO₂ stream with high precision. They also perform important quality validation and moisture checks at compressors or in liquefaction processes before captured CO₂ is transported.

During CO₂ pipeline transport, these TDLAS analyzers perform analysis in real-time, while Endress+Hauser's QF analyzers help to further avoid corrosion by detecting O₂ leaks. Endress+Hauser TDLAS and QF analyzers are demonstrably faster, more accurate, and more stable than other CCUS process measurement alternatives, with no contaminant interferences and nearly zero maintenance.

Conclusion

As energy sources and gas mixtures continue to shift, the infrastructure to capture, utilize, store, and transport CO₂ will continue to be critically important. A changing mix of molecules and pipeline infrastructure, coupled with advancement in process automation, will further drive the need for on-line gas analysis in CCUS processes for enhanced safety, asset integrity, and quality control for decades to come.

Technical specifications¹

Target component	H ₂ O in CO ₂	H ₂ S in CO ₂	O ₂ in CO ₂
Principle of measurement	Tunable diode laser absorption spectroscopy (TDLAS)	Tunable diode laser absorption spectroscopy (TDLAS)	Quenched fluorescence (QF)
Analyzer	J22	JT33, SS2100, or SS2100i	JT33 or OXY5500
Process measurement point	After dehydration, at custody transfer, after compression, and during transport	After acid gas removal, at custody transfer points	Upstream of acid gas removal, during transport
Typical measurement ranges	0 to 50 ppmv (minimum) 0 to 6000 ppmv (maximum)	0 to 10 ppmv (minimum) 0 to 5% volume (maximum)	0 to 100 ppmv (minimum) 0 to 20% volume (maximum)
Repeatability	± 1 ppmv or 1% of reading (whichever is greater)	SS2100, SS2100i: ± 250 ppbv or ± 2% of reading JT33: ± 100 ppbv or ± 1% of reading	± 1% of reading
Measurement update time ²	<5 seconds	<5 seconds	User selectable 30 seconds standard 3 seconds minimum
Sample flow rate	0.5 - 1.0 slpm (1 - 2 scfh)	0.5 - 4.0 slpm (1 - 8.5 scfh)	0.5 - 1.0 slpm (1 - 2 scfh) ³
Validation and calibration ³	No calibration required; Validation through chilled mirror, portable TDLAS, or binary cal gas	No calibration required; Validation through binary cal gas bottle with methane or nitrogen background	Calibration with zero gas (nitrogen) and span gas (H ₂ O in nitrogen)

¹ Various product models with differing features are available for this application. For complete product specifications, refer to the respective Technical Information (TI) manual or go to www.endress.com.

² Total system response dependent on flow and sample volume.

³ Consult the analyzer calibration certificate or contact Endress+Hauser prior to sourcing validation material.